

(19)



Europäisches Patentamt
European Patent Office
Office européen des brevets



(11)

EP 1 039 452 A2

(12)

EUROPEAN PATENT APPLICATION

(43) Date of publication:
27.09.2000 Bulletin 2000/39

(51) Int Cl. 7: G11B 7/007, G11B 7/013,
G11B 11/105, G11B 7/24
// G11B7/26

(21) Application number: 99118988.7

(22) Date of filing: 27.09.1999

(84) Designated Contracting States:
AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU
MC NL PT SE
Designated Extension States:
AL LT LV MK RO SI

(30) Priority: 17.03.1999 JP 7149099

(71) Applicant: FUJITSU LIMITED
Kawasaki-shi, Kanagawa 211-8588 (JP)

(72) Inventor: Morimoto, Yasuaki, c/o Fujitsu Limited
Kawasaki-shi, Kanagawa 211-8588 (JP)

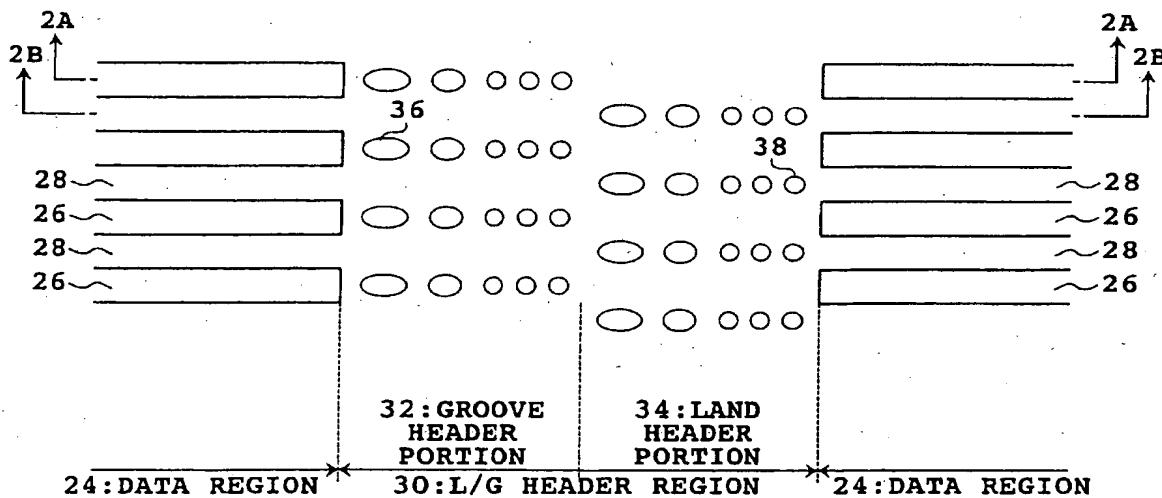
(74) Representative: Körfer, Thomas, Dipl.-Phys. et al
Mitscherlich & Partner,
Patent- und Rechtsanwälte,
Sonnenstrasse 33
80331 München (DE)

(54) Optical information storage medium having lands and grooves both serving as recording tracks

(57) An optical information recording medium having a plurality of grooves (26) and a plurality of lands (28) alternately formed. Each groove (26) and each land (28) function as recording tracks. The medium includes a first header region (34) having a plurality of first phase pits (38) respectively formed on extensions of the plurality of lands (28), and a second header region (32) having a plurality of second phase pits (36) respectively

formed on extensions of the plurality of grooves (26). Each groove (26) has an optical depth of about $3\lambda/8$ where λ is the wavelength of a light beam to be used. Each first phase pit (38) has an optical depth smaller than that of each groove (26). Each second phase pit (36) has an optical depth substantially equal to that of each groove (26). The first header region (34) and the second header region (32) are shifted from each other along the extension of each groove (26).

FIG. 1



Description**BACKGROUND OF THE INVENTION****Field of the Invention**

[0001] The present invention relates generally to an optical information storage medium having lands and grooves both serving as recording tracks, and more particularly to an optical information storage medium which can obtain a stable push-pull signal in scanning a land/groove header region with a light beam.

Description of the Related Art

[0002] An optical disk is classified generally into a read-only optical disk such as a CD-ROM, a write-once optical disk on which only writing is allowed, and a rewritable optical disk such as a magneto-optical disk and a phase-change optical disk. Such an optical disk has received attention as a memory medium that becomes a core in the recent rapid development of multimedia. A plurality of grooves are formed on a substrate of the optical disk in a concentric or spiral fashion to guide a laser beam to be directed onto the substrate. A flat portion defined between any adjacent ones of the grooves is called a land.

[0003] In a general optical disk in the prior art, either the lands or the grooves are used as recording tracks on which information is recorded. Accordingly, a header portion composed of a plurality of phase pits preliminarily formed can be configured by a greatly simple method. However, a recent important technical subject to be considered is to increase a recording density by using both the lands and the grooves as the recording tracks to thereby decrease a track pitch. In this respect, various methods for realizing this subject have already been proposed.

[0004] In a conventional optical disk adopting a land/groove recording method, the optical depth of each groove is set to about $\lambda/8$ (λ : operating wavelength) in general, and the optical depth of each phase pit in the header portion is also set to about $\lambda/8$ in general. The reason for this setting is that in a magneto-optical recording medium, for example, if the optical depth of each groove is set larger than $\lambda/8$, a reproduction signal becomes too small, whereas if the optical depth of each groove is set smaller than $\lambda/8$, a sufficient quality of a header signal itself cannot be obtained.

[0005] More specifically, the header portion consists of a land header portion for the lands as recording tracks and a groove header portion for the grooves as recording tracks. The land header portion is formed on an extension of each land in a space defined by once interrupting each groove, and the groove header portion is formed on an extension of each groove in this space. Alternatively, the land and groove header portions are formed at a mirror portion on an extension of the bound-

ary between each groove and its neighboring land. The land and groove header portions are shifted from each other in the circumferential direction of an optical disk.

[0006] As another conventional land/groove recording method, a continuous groove is formed on the substrate. The groove header portion is formed by modulating the width of each groove, and the land header portion is formed with general phase pits. Each phase pit and each groove have the same optical depth. Also in this conventional method, the land header portion and the groove header portion are not adjacent to each other in the radial direction of an optical disk. That is, the land and groove header portions are shifted from each other in the circumferential direction of an optical disk.

[0007] In the conventional land/groove recording, the grooves are formed in a data region on the substrate in a concentric or spiral fashion, and the flat land is defined between any adjacent ones of the grooves. Each groove is once interrupted at the header region. Accordingly, the groove header portion for each groove as a recording track and the land header portion for each land as a recording track are located as phase pits in the Land/Groove header region where each groove is once interrupted. The optical depth of each phase pit is set to about $\lambda/8$ (λ : operating wavelength), which is the same as the optical depth of each groove.

[0008] As a tracking error detecting method, a push-pull method and a heterodyne method, for example, are known. The push-pull method is a method utilizing the fact that the distribution of reflected light from an optical disk changes according to a positional relation between a beam spot of a laser beam focused on the optical disk by an objective lens and each groove formed on the optical disk, thereby effecting tracking error detection.

[0009] When the center of the beam spot lies on the center line of each groove, the distribution of reflected light is uniform, whereas when the center of the beam spot is deviated from the center line of each groove, the distribution of reflected light becomes nonuniform, that is, it is shifted from the center line of each groove to the right or the left.

Accordingly, tracking error detection can be performed in the following manner. A reflected beam from an optical disk is made to enter a hologram diffraction grating for equally dividing the reflected beam into two beams along a line parallel to a direction of information recording on the optical disk when the center of a beam spot directed on the optical disk lies on the center line of each groove. Then, the two beams obtained above are made to enter different photodetectors A and B. As a result, a tracking error signal TES can be expressed as follows:

$$55 \quad TES = fa - fb$$

where fa and fb are the outputs from the photodetectors A and B, respectively.

[0010] Accordingly, tracking error detection can be performed according to a value of TES.

[0011] By setting the optical depth of each groove formed on the optical disk to $\lambda/8$ where λ is the wavelength of a laser beam incident on the optical disk, a change in the distribution of reflected light due to variations in focusing position of the laser beam becomes maximum. For this reason, the optical depth of each groove is set to $\lambda/8$ in the conventional method.

[0012] In the conventional method mentioned above, the optical depth of each phase pit formed as the groove header portion for each groove serving as a recording track is the same as the optical depth of each phase pit formed as the land header portion for each land serving as a recording track. Further, the optical depth of each groove is about $\lambda/8$, and the optical depth of each phase pit is $\lambda/8$ at the maximum.

[0013] A remarkably characteristic point in this structure is that as far as the optical depth of each groove formed on the substrate of the optical disk falls within $\lambda/4$, the polarity of a so-called push-pull signal (track error signal) is constant. Since each phase pit at the groove header portion and each phase pit at the land header portion have the same optical depth, the polarities of push-pull signals with respect to both the phase pits are the same.

[0014] However, the groove header portion and the land header portion are radially shifted from each other by one track. Accordingly, when a laser beam spot scanning a certain groove track enters its Land/Groove header region, the beam spot successively scans the phase pits at the groove header portion. At this time, the polarity of a push-pull signal due to the phase pits at the groove header portion is the same as the polarity of a push-pull signal during scanning of the groove track, so that tracking servo is stably operated.

[0015] After passing the groove header portion, the beam spot scans a flat region interposed between two adjacent lines of the phase pits at the radially adjacent land header portions. Each phase pit of these land header portions defining the flat region therebetween has an optical depth of $\lambda/8$ equal to that of each groove. Accordingly, the polarity of a push-pull signal due to the phase pits at each land header portion is inverted from the polarity of a push-pull signal due to the phase pits at the groove header portion.

[0016] That is, there occurs a rapid inversion of the polarity of a push-pull signal at the boundary between the groove header portion and the successive land header portion, causing a problem that the flat region between the adjacent land header portions cannot be scanned in this case. To solve this problem, it is necessary to provide any means for detecting a timing corresponding to the above boundary and electrically inverting the polarity of a push-pull signal at the land header portion. As a result, an optical disk drive in the prior art becomes complicated in configuration.

SUMMARY OF THE INVENTION

[0017] It is therefore an object of the present invention to provide a land/groove recording type optical information storage medium which can stably obtain both a track error signal and a push-pull signal as a header signal.

[0018] In accordance with an aspect of the present invention, there is provided an optical information storage medium having a plurality of grooves and a plurality of lands alternately formed, each of said grooves and each of said lands functioning as recording tracks to form an information storage region, said optical information storage medium comprising a first header region having a plurality of first phase pits respectively formed on extensions of said plurality of lands; and a second header region having a plurality of second phase pits respectively formed on extensions of said plurality of grooves; each of said grooves having an optical depth of about $3\lambda/8$ where λ is the wavelength of a light beam to be used; each of said first phase pits having an optical depth smaller than that of each of said grooves; each of said second phase pits having an optical depth substantially equal to that of each of said grooves; said first header region and said second header region being shifted from each other along the extension of each of said grooves.

[0019] Preferably, the optical depth of each of said first phase pits is set so that the polarities of push-pull signals obtained by the light beam directed on said first and second phase pits and diffracted in a direction perpendicular to a direction of movement of said first and second phase pits are opposite to each other between said first and second phase pits, and that the polarity of a push-pull signal in said first header region is the same as the polarity of a push-pull signal generated by each land. For example, the effective optical depth of each first phase pit in the first header region is $\lambda/8$, and the optical depth of each second phase pit in the second header region is about $3\lambda/8$.

[0020] In accordance with another aspect of the present invention, there is provided an optical information storage medium having a plurality of grooves and a plurality of lands alternately formed, each of said grooves and each of said lands functioning as recording tracks to form an information storage region, said optical information storage medium comprising a first header region having a plurality of first phase pits respectively formed on extensions of said plurality of lands; and a second header region having a plurality of second phase pits respectively formed on extensions of said plurality of grooves; said first header region and said second header region being shifted from each other along an extension of each of said grooves; each of said grooves having an optical depth of $(2n + 1)\lambda/8$ where λ is the wavelength of a light beam to be used and n is a positive integer; each of said first phase pits having an optical depth of $(2n - 1 - 4m)\lambda/8$ where m is an integer not less than 0; each of said second phase pits having

an optical depth of $(2n + 1 - 4s)\lambda/8$ where s is an integer not less than 0; said n , m , and s being related so as to satisfy conditions of $2n - 1 - 4m > 0$ and $-2n + 1 - 4s > 0$. [0021] In accordance with a further aspect of the present invention, there is provided an optical information storage medium having a plurality of first grooves and a plurality of lands alternately formed, each of said first grooves and each of said lands functioning as recording tracks to form an information storage region, said optical information storage medium comprising a plurality of second grooves respectively formed on extensions of said first grooves so as to continue to said first grooves, each of said second grooves having a width smaller than that of each of said first grooves; a groove header region having a plurality of first phase pits respectively formed so as to overlap said plurality of second grooves; and a land header region having a plurality of second phase pits respectively formed on extensions of said plurality of lands so that each of said second phase pits is interposed between any adjacent ones of said second grooves; said groove header region and said land header region being shifted from each other along the extension of each first groove; all of said first grooves, said second grooves, and said first phase pits having the same optical depth of about $(2n + 1)\lambda/8$ where λ is the wavelength of a light beam to be used and n is a positive integer; each of said second phase pits having an effective optical depth of about $(2m - 1)\lambda/4$ where m is a positive integer; said n and m being related so as to satisfy a condition of $(2m - 1)\lambda/4 < (2n + 1)\lambda/8$.

[0022] Preferably, a land/groove common sector mark region is formed independently of the groove header region and the land header region in succession to the first grooves. By forming such a sector mark region common for the first grooves and the lands, the total length of the groove header region and the land header region can be reduced to thereby allow an increase in recording capacity.

[0023] The above and other objects, features and advantages of the present invention and the manner of realizing them will become more apparent, and the invention itself will best be understood from a study of the following description and appended claims with reference to the attached drawings showing some preferred embodiments of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0024]

FIG. 1 is a schematic plan view showing a substrate format according to a first preferred embodiment of the present invention;

FIG. 2A is a cross section taken along the line 2A-2A in FIG. 1;

FIG. 2B is a cross section taken along the line 2B-2B in FIG. 1;

FIG. 3A is a sectional view illustrating the optical depth of a rectangular groove, and FIG. 3B is a sectional view illustrating the optical depth of a tapered groove;

FIG. 4 is a diagram for illustrating a push-pull signal as a track error signal;

FIGS. 5A to 5C are illustrations of polarity inversion of a push-pull signal according to groove depths;

FIGS. 6A to 6C are illustrations of polarity inversion of a push-pull signal according to phase pit depths; FIG. 7 is a schematic plan view showing a substrate format in a comparison;

FIG. 8 is a schematic plan view showing a substrate format according to a second preferred embodiment of the present invention;

FIG. 9 is a schematic plan view showing a substrate format according to a third preferred embodiment of the present invention; and

FIG. 10 is a schematic diagram showing the configuration of an apparatus for manufacturing the optical information recording medium according to the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0025] Some preferred embodiments of the present invention will now be described in detail with reference to the drawings. FIG. 1 is a schematic plan view of an optical information recording medium (optical disk) according to a first preferred embodiment of the present invention, showing the structure of a header region 30 interposed between data recording regions 24 of the medium. FIG. 2A is a cross section taken along the line 2A-2A in FIG. 1, and FIG. 2B is a cross section taken along the line 2B-2B in FIG. 1. For clarity of illustration, an information recording layer formed on a substrate 22 is not shown.

[0026] A plurality of grooves 26 are formed on the substrate 22 in a concentric or spiral fashion. A flat land 28 is defined between any adjacent ones of the grooves 26. Each groove 26 as a recording track is interrupted at the header region 30. In this preferred embodiment, both the grooves 26 and the lands 28 are used as recording tracks, so that the data recording regions 24 are defined along the recording tracks of the grooves 26 and the lands 28.

[0027] The header region 30 includes a groove header portion 32 and a land header portion 34. Each of the header portions 32 and 34 is composed of a sector mark (SM), address mark (AM), and ID signal. The groove header portion 32 is formed with a plurality of lines of phase pits 36 respectively corresponding to the plurality of grooves 26. That is, the phase pits 36 in each line are arranged along the extension of the corresponding groove 26. Similarly, the land header portion 34 is formed with a plurality of lines of phase pits 38 respectively corresponding to the plurality of lands 28. That is,

the phase pits 38 in each line are arranged along the extension of the corresponding land 28. The phase pits 36 in the groove header portion 32 and the phase pits 38 in the land header portion 34 are shifted from each other in the circumferential direction of the optical disk without neighboring each other in the radial direction of the optical disk.

[0028] Letting λ denote the wavelength of a laser beam to be used, the effective optical depth of each groove 26 is set to about $3\lambda/8$, and the effective optical depth of each phase pit 36 in the groove header portion 32 is set also to about $3\lambda/8$. On the other hand, the effective optical depth of each phase pit 38 in the land header portion 34 for the lands 28 each serving as a recording track defined between any adjacent ones of the grooves 26 is set to about $\lambda/8$.

[0029] The term of "optical depth" used in this specification means a depth determined without consideration of the refractive index n of a medium through which light is passed. Further, the reason for use of the expression of "effective optical depth" is such that the cross sections of the phase pits 36 and 38 are not rectangular, but trapezoidal or tapered in an actual optical disk, so that the optical depth of each phase pit is greater a little at the deepest portion thereof. However, each phase pit behaves substantially similarly to a rectangular pit having an optical depth of $\lambda/8$, for example.

[0030] This will now be described more specifically with reference to FIGS. 3A and 3B, which are cross sections taken in the radial directions of optical disks. That is, FIG. 3A illustrates a rectangular pit or groove 40 formed on a substrate 22, and FIG. 3B illustrates a tapered or trapezoidal pit or groove 42 formed on a substrate 22. In FIG. 3A, P1 denotes the optical depth of the rectangular pit or groove 40. In FIG. 3B, P2 denotes the optical depth of the deepest portion of the tapered pit or groove 42. Reference symbol K represents a coefficient such as 1/8 and 3/8. The tapered pit or groove 42 shown in FIG. 3B is an actual pit or groove formed on an optical disk, and the optical depth P2 of the deepest portion of the tapered pit or groove 42 is set greater a little than the optical depth P1 of the rectangular pit or groove 40 shown in FIG. 3A, in order that the tapered pit or groove 42 behaves similarly to the rectangular pit or groove 40.

[0031] FIG. 4 is a diagram for illustrating tracking error detection by a push-pull signal. Reference numeral 44 denotes a two-segment photodetector divided into two segments 44a and 44b by a division line 46. Reference numeral 48 denotes a beam spot formed on the two-segment photodetector 44 by a light beam reflected from the optical information recording medium. Outputs from the segments 44a and 44b of the two-segment photodetector 44 are input into a differential amplifier 50, and an output from the differential amplifier 50 is passed through a low-pass filter 52 to output a push-pull signal as a difference between the outputs from the segments 44a and 44b.

[0032] When a laser beam scanning any one of the grooves 26 having an optical depth of $3\lambda/8$ comes to the groove header portion 32, the push-pull signal as a track error signal can be detected without inversion of

5 the polarity of the push-pull signal in the same manner as during scanning the groove 26, because the phase pits 36 each having an optical depth of $3\lambda/8$ are formed on the groove header portion 32. When the laser beam further comes to a flat portion of the land header portion 10 34 interposed between adjacent lines of the phase pits 38, the polarity of the push-pull signal is inverted from that in the case of the optical depth of $3\lambda/8$, because each phase pit 38 has an optical depth of $\lambda/8$.

[0033] The laser beam is intended to scan the flat portion (land) interposed between adjacent lines of the phase pits 38. Because of the polarity inversion of the push-pull signal mentioned above and the fact that the polarity of the push-pull signal during land scanning is inverse to the polarity of the push-pull signal during groove scanning, the push-pull signal (track error signal) having the same polarity as that during groove scanning can be obtained. Similarly, also when the laser beam scanning any one of the lands 28 comes to the header region 30, the header region 30 can be scanned without 20 changing the polarity of the push-pull signal (track error signal).

[0034] There will now be described the polarity inversion of the push-pull signal according to the groove depth and the pit depth with reference to FIGS. 5A to 30 6C. These figures are images obtained by assuming push-pull signals observed because of disk eccentricity in the case that track servo is not in an ON state. Referring to FIG. 5A, a plurality of grooves 54 and a plurality of lands 56 are alternately formed. Referring to FIG. 6A, 35 a plurality of lines of phase pits 64 are formed. Both FIGS. 5A and 6A show a condition where a beam spot 58 relatively moves at an angle with respect to the tracks (as intersecting the tracks as viewed in plan).

[0035] FIG. 5B shows a push-pull signal 60 in the case 40 that the optical depth of each groove 54 is $\lambda/8$, $5\lambda/8$, $9\lambda/8$, ..., and FIG. 5C shows a push-pull signal 62 in the case that the optical depth of each groove 54 is $3\lambda/8$, $7\lambda/8$, As apparent from FIGS. 5B and 5C, the phases of the push-pull signals 60 and 62 are shifted 180° 45 from each other according to the optical depth of each groove 54, so that the polarities of the signals 60 and 62 are inverted from each other.

[0036] FIG. 6B shows a push-pull signal 66 in the case 50 that the optical depth of each phase pit 64 is $\lambda/8$, $5\lambda/8$, $9\lambda/8$..., and FIG. 6C shows a push-pull signal 68 in the case that the optical depth of each phase pit 64 is $3\lambda/8$, $7\lambda/8$ As apparent from FIGS. 6B and 6C, the phases of the push-pull signals 66 and 68 are shifted 180° 55 from each other according to the optical depth of each phase pit 64 as similarly to the case of each groove 54 mentioned above, so that the polarities of the signals 66 and 68 are inverted from each other.

[0037] As a development of the first preferred embod-

iment obtained by expanding the above concept, the optical depth of each groove 26 may be set to $(2n + 1)\lambda/8$ (n is a positive integer), the optical depth of each phase pit 38 formed on the land header portion 34 may be set to $(2n - 1 - 4m)\lambda/8$ (m is an integer not less than 0), and the optical depth of each phase pit 36 formed on the groove header portion 32 may be set to $(2n + 1 - 4s)\lambda/8$ (s is an integer not less than 0). In this case, the relations of $2n - 1 - 4m > 0$ and $2n + 1 - 4s > 0$ must be satisfied. In the optical information recording medium including the grooves 26 and the phase pits 36 and 38 having specific optical depths according to all combinations satisfying the above conditions related to n, m, and s, a stable push-pull signal can be obtained without electrically inverting the polarity of the push-pull signal.

[0038] Accordingly, there is a possible combination such that the optical depths of each groove 26, each phase pit 36, and each phase pit 38 may be different from each other. For example, also in the case that the optical depth of each groove 26 is $5\lambda/8$, that the optical depth of each phase pit 36 on the groove header portion 32 is $\lambda/8$, and that the optical depth of each phase pit 38 on the land header portion 34 is $3\lambda/8$, an effect similar to that of the first preferred embodiment can be exhibited.

[0039] FIG. 7 is a plan view similar to FIG. 1, showing a comparison similar to the configuration of a header portion of a land/groove recording medium disclosed in Japanese Patent Laid-open No. 10-79125, for example. A plurality of grooves 70 are formed on a substrate in a concentric or spiral fashion, and a flat land 72 is defined between any adjacent ones of the grooves 70. A groove header region 74 and a land header region 76 are defined between opposite data regions where the grooves 70 and the land 72 are formed. A plurality of grooves 78 are formed in the groove header region 74 and the land header region 76 so as to respectively correspond to the plurality of grooves 70. That is, each groove 78 is formed along the extension of the corresponding groove 70. Each groove 78 has a width smaller than that of each groove 70. The groove header region 74 is further formed with a plurality of lines of phase pits 80 respectively corresponding to the plurality of grooves 78 in such a manner that the phase pits 80 in each line overlap the corresponding groove 78.

[0040] The land header region 76 is further formed with a plurality of lines of phase pits 82 respectively corresponding to the plurality of lands 72 as recording tracks. That is, the phase pits 82 in each line are arranged along the extension of the corresponding land 72 so as to be radially interposed between any adjacent ones of the grooves 78. In the configuration shown in FIG. 7, all of the grooves 70 and 78 and the phase pits 80 and 82 have the same optical depth. Although these grooves and phase pits may have different optical depths as described in Japanese Patent Laid-open No. 10-79125 cited above, no mention is made of the relation between the optical depth and the wavelength λ of

a laser beam to be used.

[0041] In the case that the optical depths of all of the grooves 70 and 78 and the phase pits 80 and 82 are set to $\lambda/8$ giving a maximum push-pull signal as a track error signal, a sufficient modulation degree of reflection from each phase pit 82 in the land header region 76 cannot be obtained because of the presence of the adjacent grooves 78 on the opposite sides. Further, a push-pull signal having a sufficient intensity cannot be obtained in the land header region 76 because of interference between a push-pull signal due to each groove 78 and a push-pull signal due to each phase pit 82.

[0042] FIG. 8 is a schematic plan view showing the configuration of a header region according to a second preferred embodiment of the present invention, solving the above problems of the comparison shown in FIG. 7. Like the configuration shown in FIG. 7, a plurality of grooves 84 are formed on a substrate in a concentric or spiral fashion, and a flat land 86 is defined between any adjacent ones of the grooves 84. A groove header region 88 and a land header region 90 are defined between opposite data regions where the grooves 84 and the lands 86 are formed. A plurality of grooves 92 are formed in the groove header region 88 and the land header region 90 so as to respectively correspond to the plurality of grooves 84. That is, each groove 92 is formed along the extension of the corresponding groove 84. Each groove 92 has a width smaller than that of each groove 84. The groove header region 88 is further formed with a plurality of lines of phase pits 94 respectively corresponding to the plurality of grooves 92 in such a manner that the phase pits 94 in each line overlap the corresponding groove 92. The land header region 90 is further formed with a plurality of lines of phase pits 96 respectively corresponding to the plurality of lands 86. That is, the phase pits 96 in each line are arranged along the extension of the corresponding land 86 so as to be radially interposed between any adjacent ones of the grooves 92.

[0043] In this preferred embodiment, the optical depths of all of the grooves 84, the grooves 92, and the phase pits 94 are set to $3\lambda/8$, and the optical depths of the phase pits 96 are set to $\lambda/4$. By setting the optical depths as mentioned above, the modulation degree of reflection from each phase pit 96 in the land header region 90 can be greatly improved. Further, the push-pull signal in the land header region 90 can also be greatly improved. The reason is that since the optical depth of each phase pit 96 is $\lambda/4$, a push-pull signal due to each phase pit 96 is not generated. Accordingly, a push-pull signal due to each groove 92 only is detected, so that stable tracking servo can be realized.

[0044] As a development of the second preferred embodiment obtained by expanding the above concept, the optical depths of all of the grooves 84, the grooves 92, and the phase pits 94 may be set to $(2n + 1)\lambda/8$ (n is a positive integer), and the effective optical depth of each phase pit 96 formed in the land header region 90 may

be set to $(2m - 1)\lambda/4$ (m is a positive integer). In this case, however, the relation of $(2m - 1)\lambda/4 < (2n + 1)\lambda/8$ must be satisfied.

[0045] FIG. 9 is a schematic plan view showing the configuration of a header region according to a third preferred embodiment of the present invention. In a general optical information recording medium, sector marks (SM) are individually located in land and groove header regions. To the contrary, this preferred embodiment employs a substrate format in the case of detecting a common sector mark for a land and a groove. A plurality of grooves 98 are formed on a substrate in a concentric or spiral fashion, and a flat land 100 is defined between any adjacent ones of the grooves 98. A groove ID region 102 and a land ID region 104 are defined between opposite data regions where the grooves 98 and the lands 100 are formed. A plurality of grooves 106 are formed in the groove ID region 102 and the land ID region 104 so as to respectively correspond to the plurality of grooves 98. That is, each groove 106 is formed along the extension of the corresponding groove 98. Each groove 106 has a width smaller than that of each groove 98.

[0046] The groove ID region 102 is further formed with a plurality of lines of phase pits 108 respectively corresponding to the plurality of grooves 106 in such a manner that the phase pits 108 in each line overlap the corresponding groove 106. Further, the land ID region 104 is further formed with a plurality of lines of phase pits 110 respectively corresponding to the plurality of lands 100. That is, the phase pits 110 in each line are arranged along the extension of the corresponding land 100 so as to be radially interposed between any adjacent ones of the grooves 106. In the groove ID region 102, the phase pits 108 are formed as an ID signal and an address mark (AM). Similarly, in the land ID region 104, the phase pits 110 are formed as an ID signal and an address mark (AM). A common sector mark region 112 is formed upstream of the groove ID region 102 so as to be circumferentially interposed between the upstream grooves 98 and the groove ID region 102. The common sector mark region 112 is formed as a plurality of lines of phase pits 114 respectively corresponding to the plurality of grooves 98. That is, the phase pits 114 in each line are arranged along the extension of the corresponding groove 98.

[0047] In scanning a certain one of the grooves 98 with a beam spot 118, the phase pit 114 irradiated with the beam spot 118 serves as a sector mark for a groove track. On the other hand, in detecting a sector mark for the land 100 as a recording track, the phase pits 114 covered with the beam spot 118 are detected as crosstalk as apparent from FIG. 9. In reproducing a land track, the phase pits 114 as a sector mark must be read as crosstalk. Accordingly, it is required that front edges 114a of the phase pits 114 adjacent to each other in the radial direction of the optical recording medium be radially aligned and that rear edges 114b of the radially ad-

jacent phase pits 114 be also radially aligned.

[0048] In a zone constant angular velocity medium (ZCAV medium), the front edges 114a must be radially aligned in a zone and the rear edges 114b must be also radially aligned in this zone. To distinguish a certain zone from its adjacent zones, each zone is generally interposed between a pair of buffer tracks 116. As mentioned above, the sector marks for groove tracks and land tracks are formed as a common sector mark, thereby allowing a reduction in total length of the header region. As a result, the area of a data recording region can be increased to thereby allow an increase in recording capacity.

[0049] A manufacturing method for the optical information recording medium according to the present invention as mentioned above will now be described. The substrate of the optical information recording medium can be obtained by first preparing a stamper from a glass master formed with grooves and prepits (phase pits) and next performing injection molding by use of the stamper. FIG. 10 is a schematic block diagram illustrating the configuration of a beam exposure apparatus used for manufacture of the optical information recording medium according to the present invention.

[0050] A photoresist having a thickness of 80 nm is formed on a polished glass master G by spin coating. The glass master G is next subjected to prebaking in a clean oven at 90° for 30 minutes. The glass master G is next placed on a table 120 of a spindle motor 132 in the beam exposure apparatus. In the beam exposure apparatus, a light beam emitted from an Ar laser source 121 is split into reflected light as a first light beam and transmitted light as a second light beam by a semitransparent mirror 122a. The first light beam reflected by the semitransparent mirror 122a enters a first condenser lens 123a. The light condensed by the first condenser lens 123a enters a first AOM (Acousto-Optic Modulator) 124a for modulation of light intensity.

[0051] The intensity-modulated light enters a first collimator lens 125a to restore a parallel light beam, which next enters a first beam expander 126a to expand the beam diameter of the parallel light beam. The parallel light beam is next reflected by a semitransparent mirror 127a to enter a semitransparent mirror 128. The first collimator lens 125a and a second collimator lens 125b which will be hereinafter described are movable in a direction perpendicular to their optical axes, thereby allowing control of a relative position between the first light beam and the second light beam.

[0052] The second light beam transmitted by the semitransparent mirror 122a enters a mirror 122b to travel a path similar to that of the first light beam. That is, the reflected light from the mirror 122b enters a second condenser lens 123b, and the resultant condensed light enters a second AOM 124b for modulation of light intensity. The intensity-modulated light output from the second AOM 124b enters a second collimator lens 125b to restore a parallel light beam, which next enters a sec-

ond beam expander 126b to expand the beam diameter. The parallel light beam from the second beam expander 126b is reflected by a mirror 127b and next transmitted by the semitransparent mirror 127a to enter the semitransparent mirror 128.

[0053] The first and second light beams transmitted by the semitransparent mirror 128 enter an optical head 129 in the condition where the relative position controlled by the first and second collimator lens 125a and 125b is maintained. The optical head 129 includes a dichroic mirror 130 and an objective lens 131, and is movable in two directions perpendicular and parallel to the table 120. The first and second light beams are reflected by the dichroic mirror 130 and focused on the glass master G by the objective lens 131.

[0054] Focusing onto the glass master G is controlled by moving the optical head 129 in the direction perpendicular to the table 120. Such focusing control is performed by irradiating the glass master G with a laser beam having a wavelength of 780 nm not sensitizing the photoresist formed on the glass master G and moving the optical head 129 in the direction perpendicular to the table 120 according to a focusing error signal based on the reflected light from the glass master G. Further, an irradiation position on the glass master G to be irradiated with the first and second light beams is controlled by moving the optical head 129 in the direction parallel to the table 120. Such parallel movement of the optical head 129 is performed by an instruction from an exposure control section 133.

[0055] The exposure control section 133 further gives instructions on exposure power to the first and second AOMs 124a and 124b to thereby control a degree of modulation of light intensity. By this control, the optical depths of the grooves and the preprints to be formed on the glass master G are controlled. The first and second light beams focused on the glass master G and reflected therefrom are reflected by the dichroic mirror 130 and next reflected by the semitransparent mirror 128 to enter a beam relative position detecting section 134, in which the relative position between the first and second light beams can be monitored.

[0056] An example of the glass master G prepared by using the above beam exposure apparatus has specific dimensions such that the pitch of grooves G1 is 1.4 μm , the depth of each groove G1 is 80 nm, the circumferential length of each preprint P1 for clock generation in a preformat portion is 0.64 μm , the circumferential length of a space between the preprints P1 is 0.64 μm , the circumferential length of each preprint P11 for information recording in the preformat portion is 2.56 μm , and the circumferential length of a space between the preprints P11 is 2.56 μm . As a miscount prevention groove G11 further formed on the glass master G, various grooves having different depths, widths, and shapes, such as V grooves having depths of 30, 60, and 80 nm and U grooves having widths of 50, 100, and 150 nm at half depths, may be obtained.

[0057] It should be noted that the above beam exposure apparatus used to prepare the glass master G is merely illustrative, and the present invention is not limited to the above preferred embodiment. For example, a visible short-wave laser or an ultraviolet laser may be used to emit the light beam. Further, an EOM (Electro-Optic Modulator) may be used to modulate the intensity of the light beam. Further, any other apparatus capable of forming the grooves and preprints on the glass master G as controlling the intensity of the light beam may be adopted.

[0058] The glass master G formed with the grooves and the preprints is put into a vacuum evaporator to deposit an Ni film having a thickness of 0.2 μm on the surface of the glass master G, thereby forming electrodes for plating. Then, an Ni film having a thickness of 0.3 mm is formed by electroplating on the glass master G. Thereafter, the Ni film thus formed by electroplating is separated from the glass master G to obtain a stamper formed of Ni. By using this stamper, injection molding is performed to obtain a polycarbonate substrate. Accordingly, the substrate is formed with grooves and preprints identical in size with those of the glass master G.

[0059] Thereafter, a recording film is formed on the substrate in the following manner. First, a base layer of SiN having a thickness of 70 nm is formed on the substrate by RF magnetron sputtering. Secondly, a reproducing layer of $\text{Gd}_{22}(\text{Fe}_{70}\text{Co}_{30})_{78}$ having a thickness of 8 nm is formed on the base layer by sputtering. Thirdly, a recording layer of $\text{Tb}_{20}(\text{Fe}_{90}\text{Co}_{10})_{80}$ having a thickness of 17 nm is formed on the reproducing layer by sputtering. Fourthly, a top layer of SiN having a thickness of 15 nm is formed on the recording layer by sputtering. Finally, a reflecting layer of Al having a thickness of 100 nm is formed on the top layer by sputtering. Thereafter, a rewritable signal is recorded at an optical recording portion of grooves G1 and lands L1 on the recording film. That is, a cyclic pattern of recording marks each having a circumferential length of 0.64 μm is recorded at the optical recording portion, thus obtaining the optical information recording medium according to the present invention.

[0060] According to the present invention as described above, a push-pull signal as a track error signal in a land/groove recording type optical information recording medium can be stably obtained. Further, in scanning the groove track or the land track with a laser beam and successively scanning the header region from its groove header portion to the land header portion, it is unnecessary to electrically invert the polarity of a push-pull signal at the boundary between the groove header portion and the land header portion, thereby simplifying the configuration of a recording/reproducing apparatus.

[0061] Further, the sector mark, address mark, and ID signal in each of the land and the groove can be stably detected, thereby easily realizing the support to decreasing of a track pitch. Further, the optical depth of

each groove is basically set to at least $3\lambda/8$ greater than $\lambda/8$ adopted in the prior art. Accordingly, in recording, erasing, or overwriting on each of the land track and the groove track, an effect of decreasing cross-writing or cross-erasing can be greatly improved, thereby supplying an optical information recording medium that can eliminate a possibility of data corruption.

Claims

1. An optical information storage medium having a plurality of grooves (26) and a plurality of lands (28) alternately formed, each of said grooves (26) and each of said lands (28) functioning as recording tracks to form an information storage region, said optical information storage medium comprising:

a first header region (34) having a plurality of first phase pits (38) respectively formed on extensions of said plurality of lands (28); and a second header region (32) having a plurality of second phase pits (36) respectively formed on extensions of said plurality of grooves (26);

wherein each of said grooves (26) has an optical depth of about $3\lambda/8$ where λ is the wavelength of a light beam to be used;

each of said first phase pits (38) has an optical depth smaller than that of each of said grooves (26);

each of said second phase pits (36) has an optical depth substantially equal to that of each of said grooves (26); and

said first header region (34) and said second header region (32) are shifted from each other along the extension of each of said grooves (26).

2. An optical information storage medium according to claim 1, wherein the optical depth of each of said first phase pits (38) is set so that the polarities of push-pull signals obtained by the light beam directed on said first and second phase pits (36, 38) and diffracted in a direction perpendicular to a direction of movement of said first and second phase pits (36, 38) are opposite to each other between said first and second phase pits (36, 38) and that the polarity of a push-pull signal in said first header region (34) is the same as the polarity of a push-pull signal generated by each land (28).

3. An optical information storage medium according to claim 2, wherein each of said first phase pits (38) has an effective optical depth of $\lambda/8$.

4. An optical information storage medium having a

5 plurality of grooves (26) and a plurality of lands (28) alternately formed, each of said grooves (26) and each of said lands (28) functioning as recording tracks to form an information storage region, said optical information storage medium comprising:

a first header region (34) having a plurality of first phase pits (38) respectively formed on extensions of said plurality of lands (28); and a second header region (32) having a plurality of second phase pits (36) respectively formed on extensions of said plurality of grooves (26);

10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100 105 110 115 120 125 130 135 140 145 150 155 160 165 170 175 180 185 190 195 200 205 210 215 220 225 230 235 240 245 250 255 260 265 270 275 280 285 290 295 300 305 310 315 320 325 330 335 340 345 350 355 360 365 370 375 380 385 390 395 400 405 410 415 420 425 430 435 440 445 450 455 460 465 470 475 480 485 490 495 500 505 510 515 520 525 530 535 540 545 550 555 560 565 570 575 580 585 590 595 600 605 610 615 620 625 630 635 640 645 650 655 660 665 670 675 680 685 690 695 700 705 710 715 720 725 730 735 740 745 750 755 760 765 770 775 780 785 790 795 800 805 810 815 820 825 830 835 840 845 850 855 860 865 870 875 880 885 890 895 900 905 910 915 920 925 930 935 940 945 950 955 960 965 970 975 980 985 990 995 1000 1005 1010 1015 1020 1025 1030 1035 1040 1045 1050 1055 1060 1065 1070 1075 1080 1085 1090 1095 1100 1105 1110 1115 1120 1125 1130 1135 1140 1145 1150 1155 1160 1165 1170 1175 1180 1185 1190 1195 1200 1205 1210 1215 1220 1225 1230 1235 1240 1245 1250 1255 1260 1265 1270 1275 1280 1285 1290 1295 1300 1305 1310 1315 1320 1325 1330 1335 1340 1345 1350 1355 1360 1365 1370 1375 1380 1385 1390 1395 1400 1405 1410 1415 1420 1425 1430 1435 1440 1445 1450 1455 1460 1465 1470 1475 1480 1485 1490 1495 1500 1505 1510 1515 1520 1525 1530 1535 1540 1545 1550 1555 1560 1565 1570 1575 1580 1585 1590 1595 1600 1605 1610 1615 1620 1625 1630 1635 1640 1645 1650 1655 1660 1665 1670 1675 1680 1685 1690 1695 1700 1705 1710 1715 1720 1725 1730 1735 1740 1745 1750 1755 1760 1765 1770 1775 1780 1785 1790 1795 1800 1805 1810 1815 1820 1825 1830 1835 1840 1845 1850 1855 1860 1865 1870 1875 1880 1885 1890 1895 1900 1905 1910 1915 1920 1925 1930 1935 1940 1945 1950 1955 1960 1965 1970 1975 1980 1985 1990 1995 2000 2005 2010 2015 2020 2025 2030 2035 2040 2045 2050 2055 2060 2065 2070 2075 2080 2085 2090 2095 2100 2105 2110 2115 2120 2125 2130 2135 2140 2145 2150 2155 2160 2165 2170 2175 2180 2185 2190 2195 2200 2205 2210 2215 2220 2225 2230 2235 2240 2245 2250 2255 2260 2265 2270 2275 2280 2285 2290 2295 2300 2305 2310 2315 2320 2325 2330 2335 2340 2345 2350 2355 2360 2365 2370 2375 2380 2385 2390 2395 2400 2405 2410 2415 2420 2425 2430 2435 2440 2445 2450 2455 2460 2465 2470 2475 2480 2485 2490 2495 2500 2505 2510 2515 2520 2525 2530 2535 2540 2545 2550 2555 2560 2565 2570 2575 2580 2585 2590 2595 2600 2605 2610 2615 2620 2625 2630 2635 2640 2645 2650 2655 2660 2665 2670 2675 2680 2685 2690 2695 2700 2705 2710 2715 2720 2725 2730 2735 2740 2745 2750 2755 2760 2765 2770 2775 2780 2785 2790 2795 2800 2805 2810 2815 2820 2825 2830 2835 2840 2845 2850 2855 2860 2865 2870 2875 2880 2885 2890 2895 2900 2905 2910 2915 2920 2925 2930 2935 2940 2945 2950 2955 2960 2965 2970 2975 2980 2985 2990 2995 3000 3005 3010 3015 3020 3025 3030 3035 3040 3045 3050 3055 3060 3065 3070 3075 3080 3085 3090 3095 3100 3105 3110 3115 3120 3125 3130 3135 3140 3145 3150 3155 3160 3165 3170 3175 3180 3185 3190 3195 3200 3205 3210 3215 3220 3225 3230 3235 3240 3245 3250 3255 3260 3265 3270 3275 3280 3285 3290 3295 3300 3305 3310 3315 3320 3325 3330 3335 3340 3345 3350 3355 3360 3365 3370 3375 3380 3385 3390 3395 3400 3405 3410 3415 3420 3425 3430 3435 3440 3445 3450 3455 3460 3465 3470 3475 3480 3485 3490 3495 3500 3505 3510 3515 3520 3525 3530 3535 3540 3545 3550 3555 3560 3565 3570 3575 3580 3585 3590 3595 3600 3605 3610 3615 3620 3625 3630 3635 3640 3645 3650 3655 3660 3665 3670 3675 3680 3685 3690 3695 3700 3705 3710 3715 3720 3725 3730 3735 3740 3745 3750 3755 3760 3765 3770 3775 3780 3785 3790 3795 3800 3805 3810 3815 3820 3825 3830 3835 3840 3845 3850 3855 3860 3865 3870 3875 3880 3885 3890 3895 3900 3905 3910 3915 3920 3925 3930 3935 3940 3945 3950 3955 3960 3965 3970 3975 3980 3985 3990 3995 4000 4005 4010 4015 4020 4025 4030 4035 4040 4045 4050 4055 4060 4065 4070 4075 4080 4085 4090 4095 4100 4105 4110 4115 4120 4125 4130 4135 4140 4145 4150 4155 4160 4165 4170 4175 4180 4185 4190 4195 4200 4205 4210 4215 4220 4225 4230 4235 4240 4245 4250 4255 4260 4265 4270 4275 4280 4285 4290 4295 4300 4305 4310 4315 4320 4325 4330 4335 4340 4345 4350 4355 4360 4365 4370 4375 4380 4385 4390 4395 4400 4405 4410 4415 4420 4425 4430 4435 4440 4445 4450 4455 4460 4465 4470 4475 4480 4485 4490 4495 4500 4505 4510 4515 4520 4525 4530 4535 4540 4545 4550 4555 4560 4565 4570 4575 4580 4585 4590 4595 4600 4605 4610 4615 4620 4625 4630 4635 4640 4645 4650 4655 4660 4665 4670 4675 4680 4685 4690 4695 4700 4705 4710 4715 4720 4725 4730 4735 4740 4745 4750 4755 4760 4765 4770 4775 4780 4785 4790 4795 4800 4805 4810 4815 4820 4825 4830 4835 4840 4845 4850 4855 4860 4865 4870 4875 4880 4885 4890 4895 4900 4905 4910 4915 4920 4925 4930 4935 4940 4945 4950 4955 4960 4965 4970 4975 4980 4985 4990 4995 5000 5005 5010 5015 5020 5025 5030 5035 5040 5045 5050 5055 5060 5065 5070 5075 5080 5085 5090 5095 5100 5105 5110 5115 5120 5125 5130 5135 5140 5145 5150 5155 5160 5165 5170 5175 5180 5185 5190 5195 5200 5205 5210 5215 5220 5225 5230 5235 5240 5245 5250 5255 5260 5265 5270 5275 5280 5285 5290 5295 5300 5305 5310 5315 5320 5325 5330 5335 5340 5345 5350 5355 5360 5365 5370 5375 5380 5385 5390 5395 5400 5405 5410 5415 5420 5425 5430 5435 5440 5445 5450 5455 5460 5465 5470 5475 5480 5485 5490 5495 5500 5505 5510 5515 5520 5525 5530 5535 5540 5545 5550 5555 5560 5565 5570 5575 5580 5585 5590 5595 5600 5605 5610 5615 5620 5625 5630 5635 5640 5645 5650 5655 5660 5665 5670 5675 5680 5685 5690 5695 5700 5705 5710 5715 5720 5725 5730 5735 5740 5745 5750 5755 5760 5765 5770 5775 5780 5785 5790 5795 5800 5805 5810 5815 5820 5825 5830 5835 5840 5845 5850 5855 5860 5865 5870 5875 5880 5885 5890 5895 5900 5905 5910 5915 5920 5925 5930 5935 5940 5945 5950 5955 5960 5965 5970 5975 5980 5985 5990 5995 6000 6005 6010 6015 6020 6025 6030 6035 6040 6045 6050 6055 6060 6065 6070 6075 6080 6085 6090 6095 6100 6105 6110 6115 6120 6125 6130 6135 6140 6145 6150 6155 6160 6165 6170 6175 6180 6185 6190 6195 6200 6205 6210 6215 6220 6225 6230 6235 6240 6245 6250 6255 6260 6265 6270 6275 6280 6285 6290 6295 6300 6305 6310 6315 6320 6325 6330 6335 6340 6345 6350 6355 6360 6365 6370 6375 6380 6385 6390 6395 6400 6405 6410 6415 6420 6425 6430 6435 6440 6445 6450 6455 6460 6465 6470 6475 6480 6485 6490 6495 6500 6505 6510 6515 6520 6525 6530 6535 6540 6545 6550 6555 6560 6565 6570 6575 6580 6585 6590 6595 6600 6605 6610 6615 6620 6625 6630 6635 6640 6645 6650 6655 6660 6665 6670 6675 6680 6685 6690 6695 6700 6705 6710 6715 6720 6725 6730 6735 6740 6745 6750 6755 6760 6765 6770 6775 6780 6785 6790 6795 6800 6805 6810 6815 6820 6825 6830 6835 6840 6845 6850 6855 6860 6865 6870 6875 6880 6885 6890 6895 6900 6905 6910 6915 6920 6925 6930 6935 6940 6945 6950 6955 6960 6965 6970 6975 6980 6985 6990 6995 7000 7005 7010 7015 7020 7025 7030 7035 7040 7045 7050 7055 7060 7065 7070 7075 7080 7085 7090 7095 7100 7105 7110 7115 7120 7125 7130 7135 7140 7145 7150 7155 7160 7165 7170 7175 7180 7185 7190 7195 7200 7205 7210 7215 7220 7225 7230 7235 7240 7245 7250 7255 7260 7265 7270 7275 7280 7285 7290 7295 7300 7305 7310 7315 7320 7325 7330 7335 7340 7345 7350 7355 7360 7365 7370 7375 7380 7385 7390 7395 7400 7405 7410 7415 7420 7425 7430 7435 7440 7445 7450 7455 7460 7465 7470 7475 7480 7485 7490 7495 7500 7505 7510 7515 7520 7525 7530 7535 7540 7545 7550 7555 7560 7565 7570 7575 7580 7585 7590 7595 7600 7605 7610 7615 7620 7625 7630 7635 7640 7645 7650 7655 7660 7665 7670 7675 7680 7685 7690 7695 7700 7705 7710 7715 7720 7725 7730 7735 7740 7745 7750 7755 7760 7765 7770 7775 7780 7785 7790 7795 7800 7805 7810 7815 7820 7825 7830 7835 7840 7845 7850 7855 7860 7865 7870 7875 7880 7885 7890 7895 7900 7905 7910 7915 7920 7925 7930 7935 7940 7945 7950 7955 7960 7965 7970 7975 7980 7985 7990 7995 8000 8005 8010 8015 8020 8025 8030 8035 8040 8045 8050 8055 8060 8065 8070 8075 8080 8085 8090 8095 8100 8105 8110 8115 8120 8125 8130 8135 8140 8145 8150 8155 8160 8165 8170 8175 8180 8185 8190 8195 8200 8205 8210 8215 8220 8225 8230 8235 8240 8245 8250 8255 8260 8265 8270 8275 8280 8285 8290 8295 8300 8305 8310 8315 8320 8325 8330 8335 8340 8345 8350 8355 8360 8365 8370 8375 8380 8385 8390 8395 8400 8405 8410 8415 8420 8425 8430 8435 8440 8445 8450 8455 8460 8465 8470 8475 8480 8485 8490 8495 8500 8505 8510 8515 8520 8525 8530 8535 8540 8545 8550 8555 8560 8565 8570 8575 8580 8585 8590 8595 8600 8605 8610 8615 8620 8625 8630 8635 8640 8645 8650 8655 8660 8665 8670 8675 8680 8685 8690 8695 8700 8705 8710 8715 8720 8725 8730 8735 8740 8745 8750 8755 8760 8765 8770 8775 8780 8785 8790 8795 8800 8805 8810 8815 8820 8825 8830 8835 8840 8845 8850 8855 8860 8865 8870 8875 8880 8885 8890 8895 8900 8905 8910 8915 8920 8925 8930 8935 8940 8945 8950 8955 8960 8965 8970 8975 8980 8985 8990 8995 9000 9005 9010 9015 9020 9025 9030 9035 9040 9045 9050 9055 9060 9065 9070 9075 9080 9085 9090 9095 9100 9105 9110 9115 9120 9125 9130 9135 9140 9145 9150 9155 9160 9165 9170 9175 9180 9185 9190 9195 9200 9205 9210 9215 9220 9225 9230 9235 9240 9245 9250 9255 9260 9265 9270 9275 9280 9285 9290 9295 9300 9305 9310 9315 9320 9325 9330 9335 9340 9345 9350 9355 9360 9365 9370 9375 9380 9385 9390 9395 9400 9405 9410 9415 9420 9425 9430 9435 9440 9445 9450 9455 9460 9465 9470 9475 9480 9485 9490 9495 9500 9505 9510 9515 9520 9525 9530 9535 9540 9545 9550 9555 9560 9565 9570 9575 9580 9585 9590 9595 9600 9605 9610 9615 9620 9625 9630 9635 9640 9645 9650 9655 9660 9665 9670 9675 9680 9685 9690 9695 9700 9705 9710 9715 9720 9725 9730 9735 9740 9745 9750 9755 9760 9765 9770 9775 9780 9785 9790 9795 9800 9805 9810 9815 9820 9825 9830 9835 9840 9845 9850 9855 9860 9865 9870 9875 9880 9885 9890 9895 9900 9905 9910 9915 9920 9925 9930 9935 9940 9945 9950 9955 9960 9965 9970 9975 9980 9985 9990 9995 9999

ones of said second grooves (92, 106);

wherein said groove header region (88, 102) and said land header region (90, 104) are shifted from each other along the extension of each first groove (84, 98);

all of said first grooves (84, 98), said second grooves (92, 106), and said first phase pits (94, 108) have the same optical depth of about $(2n + 1)\lambda/8$ where λ is the wavelength of a light beam to be used and n is a positive integer; each of said second phase pits (96, 110) has an effective optical depth of about $(2m - 1)\lambda/4$ where m is a positive integer; and said n and m are related so as to satisfy a condition of $(2m - 1)\lambda/4 < (2n + 1)\lambda/8$.

7. An optical information storage medium according to claim 6, wherein:

the optical depths of all of said first grooves (84, 98) said second grooves (92, 106), and said first phase pits (94, 108) are set to about $3\lambda/8$; and
the optical depth of each of said second phase pits (96, 110) is set to about $\lambda/4$.

8. An optical information storage medium according to claim 6, further comprising a common sector mark region (112) having a plurality of sector marks as third phase pits (114) respectively corresponding to said plurality of first grooves (98), each of said third phase pits (114) having an optical depth equal to that of each of said first grooves (98) and a width substantially equal to that of each of said first grooves (98).

9. An optical information storage medium according to claim 8, wherein said sector marks (114) have front edges (114a) and rear edges (114b) both aligned in a direction perpendicular to an extension of each of said first grooves (98).

5

10

19

1

25

30

35

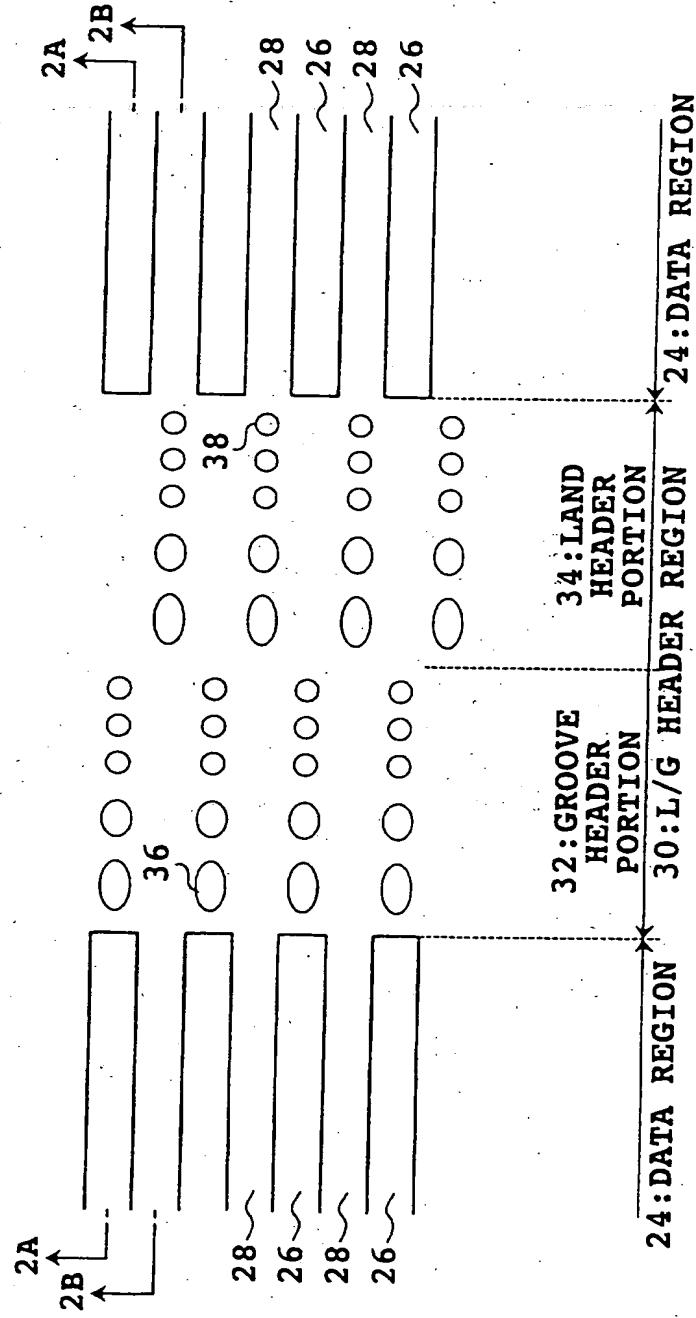
40

45

56

55

FIG. 1



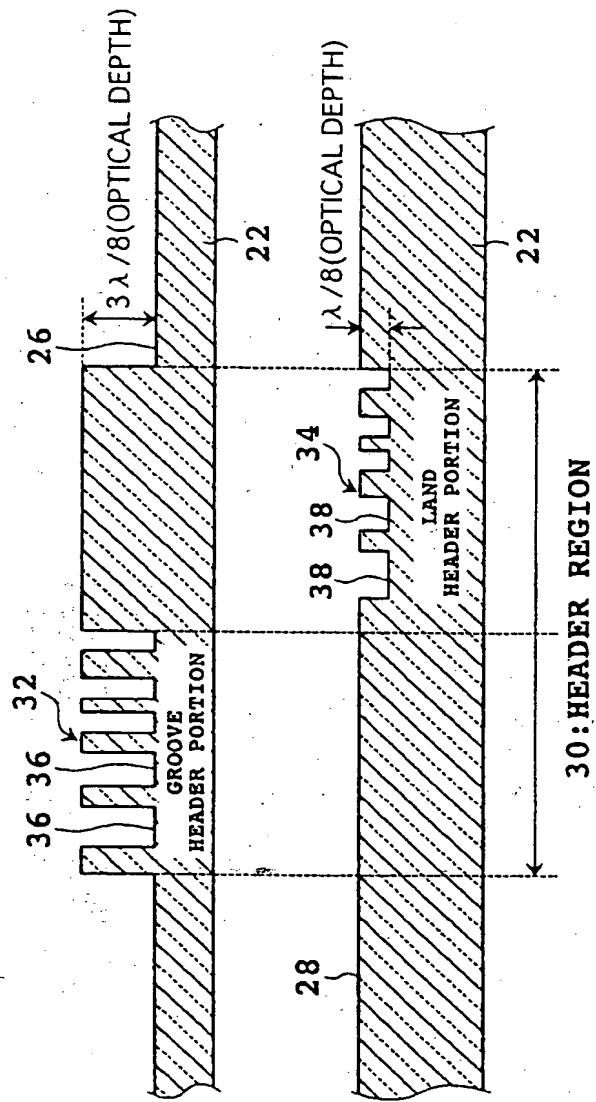


FIG. 3 A

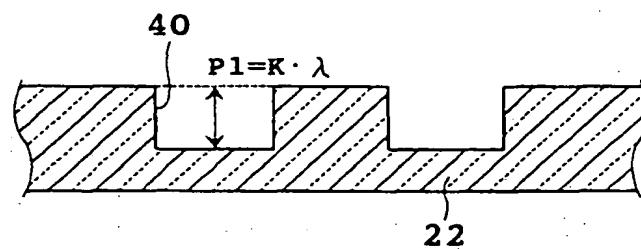
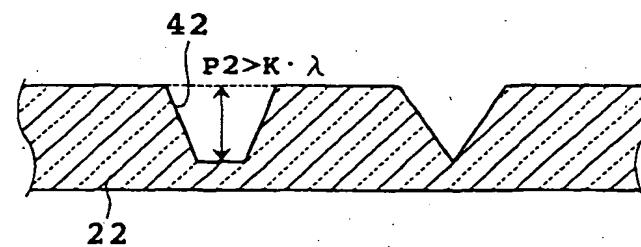


FIG. 3 B



F I G. 4

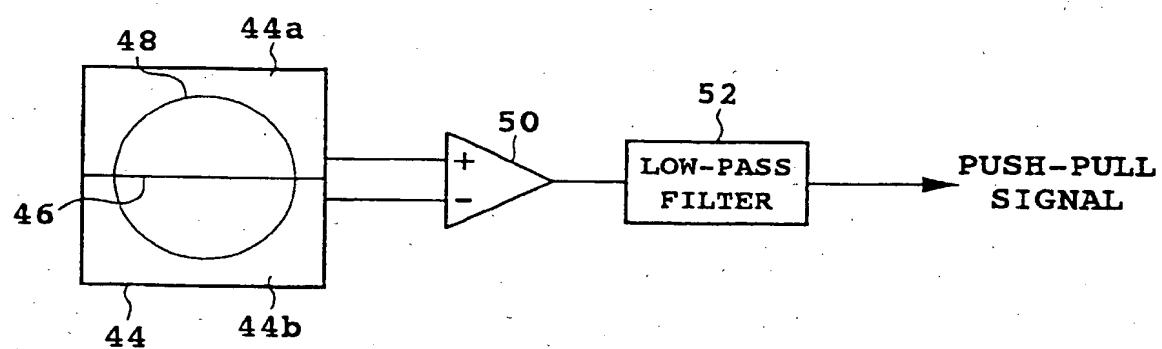


FIG.5A

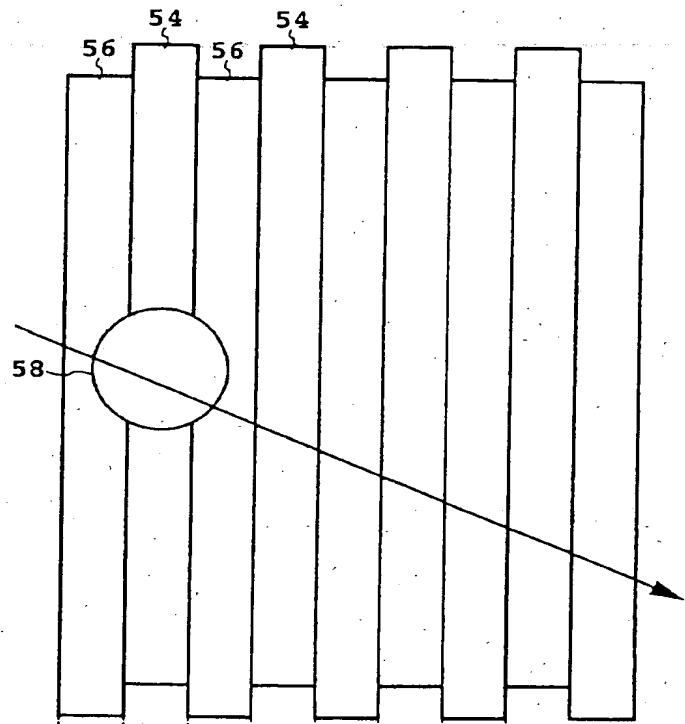


FIG.5B

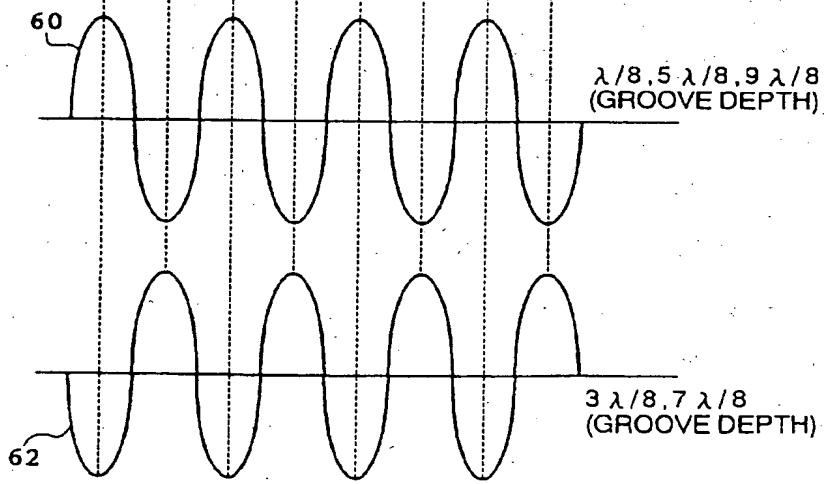


FIG.5C

FIG.6A

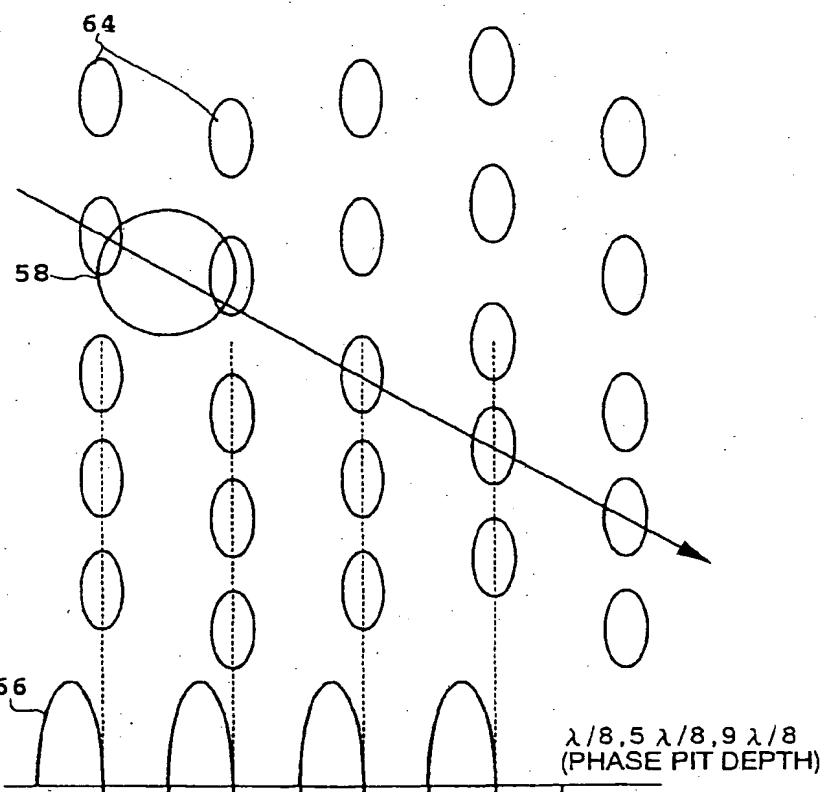


FIG.6B

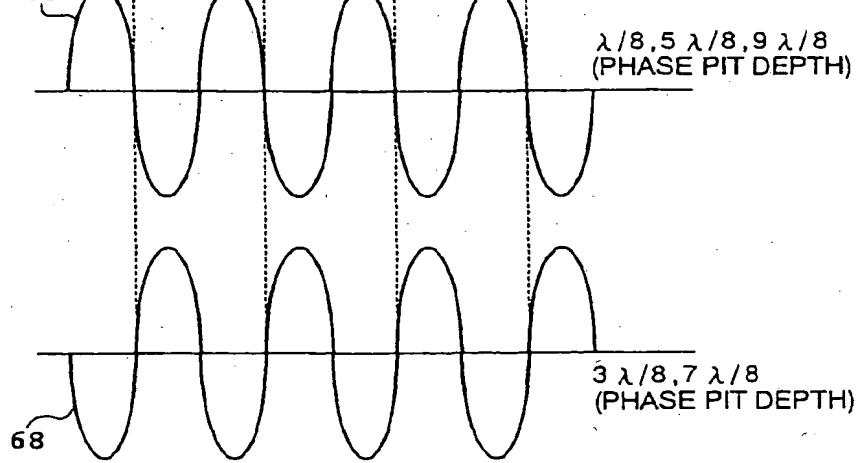


FIG.6C

FIG. 7

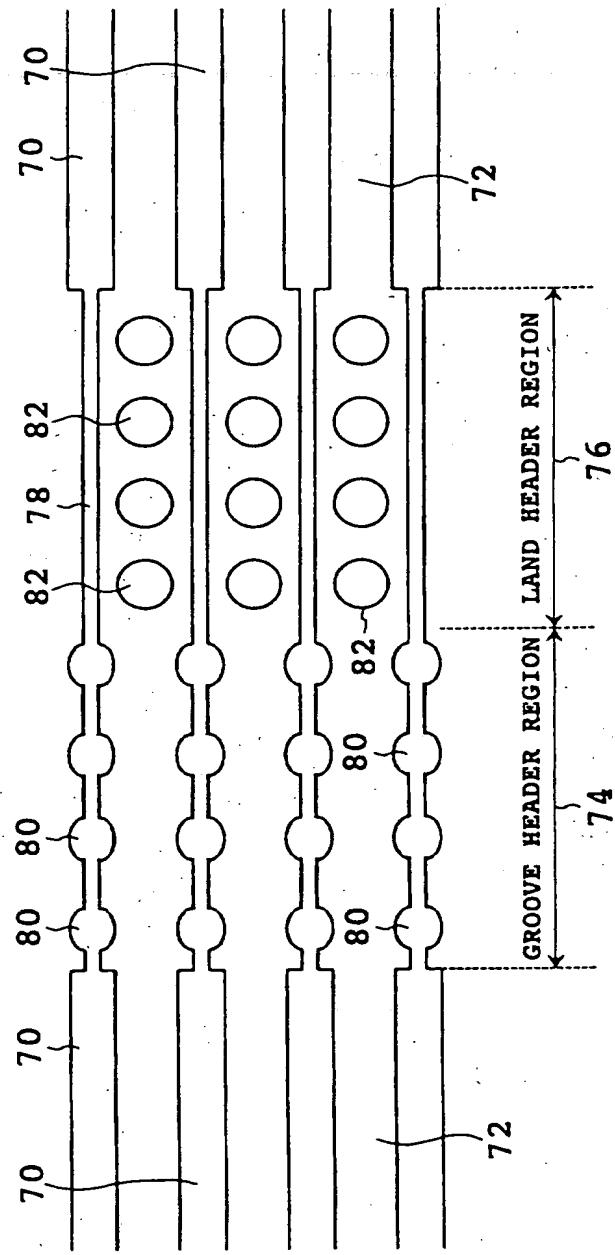


FIG. 8

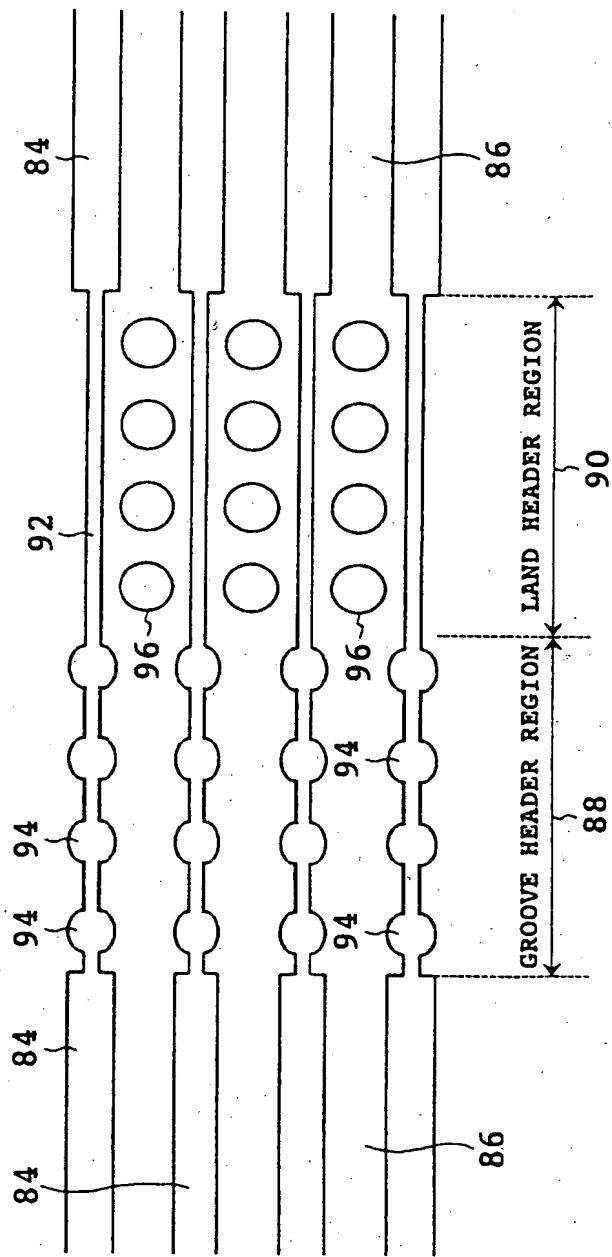
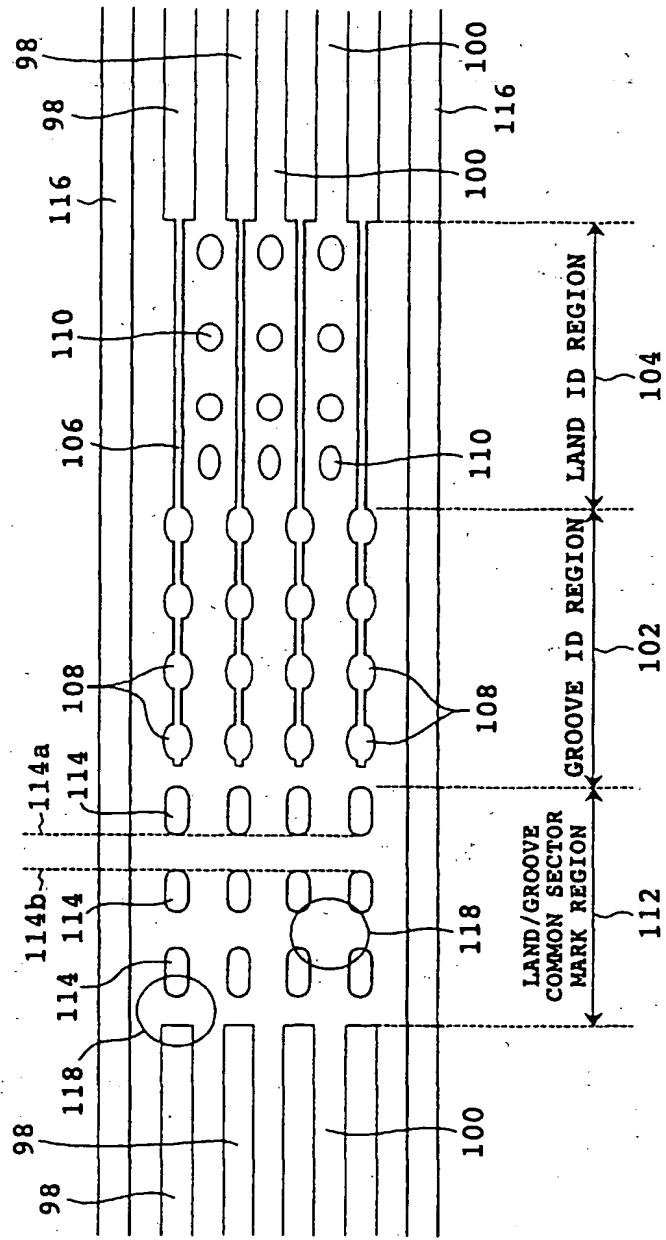


FIG. 9

EP 1 039 452 A2



F I G. 1 0

